

## *SUPERSTITIOUS KEY PECKING AFTER THREE PECK-PRODUCED REINFORCEMENTS<sup>1</sup>*

ALLEN J. NEURINGER

FOUNDATION FOR RESEARCH ON THE NERVOUS SYSTEM

The first three pecks on a response key by experimentally naive pigeons produced grain reinforcements. Thereafter, for approximately 50 experimental sessions and under a variety of schedule conditions, grain was presented independently of the subjects' behaviors. The pigeons continued to peck the response key "superstitiously" throughout the 50 sessions. The results suggest that superstitions are commonplace—not relatively infrequent or abnormal events—in the behavior of pigeons.

Animals sometimes repeat specific patterns of behavior despite the fact that the behavior does not result in reinforcement. Such repetitive but noncausal responding is called "superstitious" responding after the human phenomenon (Skinner, 1948). For example, a man might murmur "let's go baby, let's go baby" while the roulette wheel revolves; analogously, when Skinner (1948) presented food without regard to a pigeon's behavior, the bird nevertheless turned repeatedly in a circle. The superstitious "let's go baby" presumably has no more effect on a roulette wheel than did the superstitious turning have on the presentation of food. In Skinner's original demonstration of animal superstition, food was presented every 15 sec to hungry pigeons no matter how they behaved (an operation described as the response-independent, or noncontingent, presentation of food). Although the occurrence of reinforcement was in no way influenced by the pigeons' behaviors, six of eight subjects eventually emitted stereotyped, superstitious responses: the bird described above turned in circles; another repeatedly thrust its head into a corner of the cage; two birds swung their heads from right to left; the fifth tossed its head up and down; and the sixth bird made incomplete pecking movements toward the floor.

The present study explored the formation of a superstitious response; in particular, the

experiment asks whether relatively few reinforcements are sufficient to establish a superstition. Skinner (1948, pp. 168-169) suggested that superstitions are formed in the following way: "The bird happens to be executing some response as the (food) hopper appears; as a result it tends to repeat this response. If the interval before the next presentation is not so great that extinction takes place, a second 'contingency' is probable. This strengthens the response still further and subsequent reinforcement (of the response) becomes more probable. It is true that some responses go unreinforced and some reinforcements appear when the response has not just been made, but the net result is the development of a considerable state of strength." This analysis implies that a single accidental correlation between act and response-independent reinforcement begins the process leading to the establishment of the superstition. However, Herrnstein (1966, p. 35) offered the following possible objection: ". . . since the sorts of acts that Skinner reported, such as head bobbing and pecking, are distinctly pigeon-like, his procedure may have simply accentuated the very forms of response that were initially dominant among the pigeons." In other words, the superstitions might have been at high strength before the experiment, and therefore Skinner could not have determined the number of response-reinforcement correlations necessary to establish the superstition. Other experiments on superstitious responding have not dealt with this problem. Most have used a response that in all likelihood had to be learned within the experimental chamber, the arbitrary key-peck response (Morse and Skinner, 1957; Appel and

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Hiss, 1962; Herrnstein, 1966; Zeiler, 1968; Edwards, West, and Jackson, 1968; Rescorla and Skucy, 1969). But the subjects in each of these experiments received hundreds or thousands of response-produced reinforcements for key pecking *before* responding superstitiously on the key. Thus, all animals that have behaved superstitiously in experimental environments first received either an unknown number or a large number of response-correlated reinforcements.

In the present study, the first three key pecks made by hungry, naive pigeons were immediately followed by the presentation of food. Then, for approximately 50 experimental sessions, food occurred independently of the pigeons' behaviors. The question asked is whether a newly learned response can be strengthened and maintained by response-independent reinforcements. The answer might suggest the relative frequency of occurrence, and therefore the importance, of superstitious responding in extra-laboratory environments.

## EXPERIMENT I: RESPONSE-INDEPENDENT VARIABLE-INTERVAL

### METHOD

#### *Subjects*

Eleven male White Carneaux pigeons, with no previous experience in experiments, were maintained at approximately 85% of their free-feeding body weights.

#### *Apparatus*

A standard experimental chamber contained a translucent Gerbrands response key and a feeder that gave access to mixed grain when operated. The key was transilluminated by a 7-w General Electric red bulb except when the feeder was operated; during that time a 7-w G.E. white bulb illuminated the accessible grain. Pecks on the response key of at least 15 g (0.15 N) force were recorded and produced feedback flashes from four overhead white 7-w G.E. bulbs operated off of the pulse former (each flash lasting 30 msec). There was no additional illumination in the chamber (*i.e.*, no houselight). The experiment was controlled automatically by the use of relays, timers, *etc.*

#### *Procedure*

*Preliminary training.* All birds were first trained to eat from the feeder in the following way: a subject was placed in the chamber with the key lighted, the feeder lighted and operated so that grain was easily accessible, and about 3 g of grain scattered on the floor in front of the feeder. The apparatus remained in this condition until the bird approached the feeder and ate from it for at least 10 sec, at which time the grain was removed and then twice presented again until, each time, the bird received 5-sec access to the grain. Thirty response-independent feeder operations then occurred on a 30-sec variable-interval (VI) schedule. Each time the feeder operated, the subject was permitted to eat for 5 sec. By the thirtieth training trial all birds approached the feeder as soon as it operated and, except when noted, the feeder operated for a constant 5 sec in all successive phases of the experiment. After this preliminary training, the subjects were divided into three groups, each of which will be discussed individually.

*Experimental group.* After learning to eat from the feeder, each of four birds was individually placed in the experimental chamber with the key lighted. No food was presented until the subject pecked the key, at which time (a) there was a feedback flash from the overhead lights, (b) the feeder was operated for 15 sec, and (c) the key was darkened while grain was accessible. Note that no attempt was made to shape (*i.e.*, teach) the bird to respond: the bird simply remained in the chamber until a key peck occurred. The next two key pecks each produced the same constellation of events; thus, the first three responses produced immediate access to grain. The average time before the first response for three of the subjects was 176 min; the fourth subject did not respond during a total of 3250 min, distributed over four sessions, and was therefore withdrawn from the experiment.

After the third response-produced reinforcement, pecks no longer produced, nor influenced in any way, the presentation of food. For the remainder of the first session, and during the next 19 sessions, pecks produced only feedback flashes from the overhead lights. Access to grain was controlled by the same response-independent 30-sec variable-interval schedule used in preliminary training: on the

average of once every 30 sec, grain was presented for 5 sec independently of the birds' behaviors. The key went dark whenever the feeder was operated. Forty-five feeder operations occurred each session for 20 sessions.

*Extinction control group.* The responses emitted by the birds in the experimental condition described above might have been caused solely by the original three response-produced reinforcements, or solely by the response-independent feeder operations occurring thereafter, or by a combination of these. In the first of the two control conditions, four pigeons received only three response-produced reinforcements, after which grain was never again presented in the experimental chamber, a condition referred to as "extinction." Before extinction began, or until the subject received its third response-produced reinforcement, the procedure was identical to that described above. Three of four subjects made their first key peck with an average latency of 182 min. The fourth subject did not respond in a total of 4541 min, distributed over five sessions, and was withdrawn from the experiment. After the third response-produced reinforcement, no food was presented during the remainder of the first session or during the next 19 sessions. Responses to the key continued to produce feedback flashes from the overhead lights, as in the experimental condition, but the feeder was never operated and consequently, the key was never darkened. Each session terminated after 22.5 min, the approximate time of the experimental birds' sessions.

*Response-independent control group.* To determine whether the responses made by the experimental birds were caused solely by the response-independent presentation of grain (or by any other experimental parameter, *e.g.*, the keylight going out during grain presentation), or whether key pecking was a probable response before the beginning of this experiment, three birds were placed directly on the response-independent VI 30-sec schedule. With the single exception that these birds never received response-produced reinforcements, this condition was identical to the experimental condition: responses were followed by feedback flashes from the overhead lights; during grain presentation the feeder was lighted and the key darkened, *etc.* Forty-five feeder operations occurred during each of 10 sessions conducted.

## RESULTS

The birds that received three response-produced reinforcements followed by response-independent grain (*i.e.*, those in the experimental group) responded considerably more than did any control bird. Figure 1 shows the total number of responses emitted by each of the birds in this part of the experiment. The experimental birds made an average total of about 2700 responses; the extinction control birds made approximately 150 responses; and the response-independent control birds emitted an average of two responses.

The experimental birds' average rates of responding per session are shown in the insert of Fig. 1. Note that the vertical axis is logarithmic and, therefore, that the decrease in response rate is compressed. Selected cumulative records for one experimental subject, #55, are given in Fig. 2. Rates of responding by the experimental birds were first relatively high and then decreased to a low level. During no session, however, did responding cease altogether (*i.e.*, extinguish). On the other hand, the number of responses in a session emitted by each extinction control bird declined to zero: #61 in the third session, #56 in the eighth, and #60 in the thirteenth. Two subjects in the response-independent control group did not respond at all, while the third bird emitted six responses during the first session and never responded thereafter. In conclusion, the combination of three reinforced key pecks followed by response-independent grain presentations produced considerably more responding than did either of these conditions alone.

## EXPERIMENT II: VARYING RATE AND SCHEDULE OF RESPONSE-INDEPENDENT GRAIN

This experiment explored three possible ways to increase the rates of emission of a superstitious response. First, the frequency of presentation of response-independent grain was decreased. The rationale for this was derived from studies of operant behavior where temporary increases in response rates are found when reinforcement rates decrease (Fester and Skinner, 1957). Second, two subjects were removed from the experiment for a period of three months and then returned.

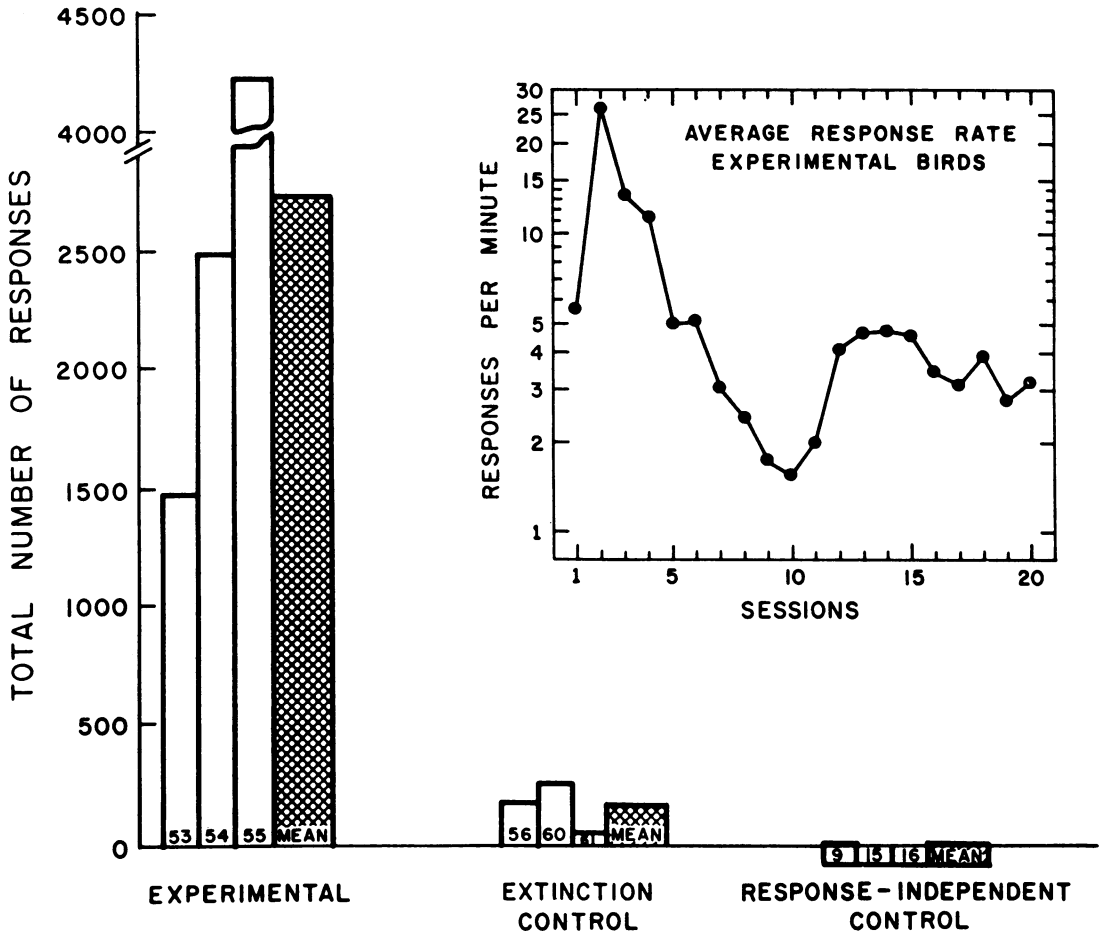


Fig. 1. Total number of responses made by each subject, and mean number of responses for each group of subjects in Exp. I. See text for explanation of group titles. The insert shows the average of the three experimental birds' rates of responding during each session in Exp. I. Note the logarithmic vertical axis.

Finally, the schedule of response-independent grain was changed from variable to fixed interval.

#### METHOD

##### Subjects

Immediately after the termination of Exp. I, Subjects 53, 54, and 55 were placed in this experiment.

##### Apparatus

Same as in Exp. I.

##### Procedure

The procedures are presented separately for each bird.

**Subject 53:** The schedule of response-independent food was changed from VI 30-sec to VI 1-min for three sessions, and then to VI 2-min for 25 sessions. Except for these decreases in the frequency of grain presentation, the procedure throughout was identical to that in Exp. I (experimental condition).

**Subject 54:** The schedule of response-independent food was changed to VI 1-min for five sessions and then to VI 2-min for five sessions. This subject was then removed from the experiment and maintained at 85% of its normal weight in its living cage for approximately three months, after which it was returned to the same response-independent VI 2-min schedule for two sessions. A response-independent 2-min fixed-interval (FI) schedule was

then instituted for 20 sessions. The only difference between the VI and the FI schedules was that in the first, food occurred randomly

in time, whereas in the second, food occurred periodically every 2 min.

Subject 55: The response-independent VI 30-sec schedule used in Exp. I was continued for another 10 sessions, after which the same series of procedures as described above for #54 was instituted: three sessions under VI 1-min, seven sessions under VI 2-min, three months removal from the experiment, two sessions under VI 2-min, and, finally, 15 sessions under FI 2-min. Access to grain was response-independent throughout.

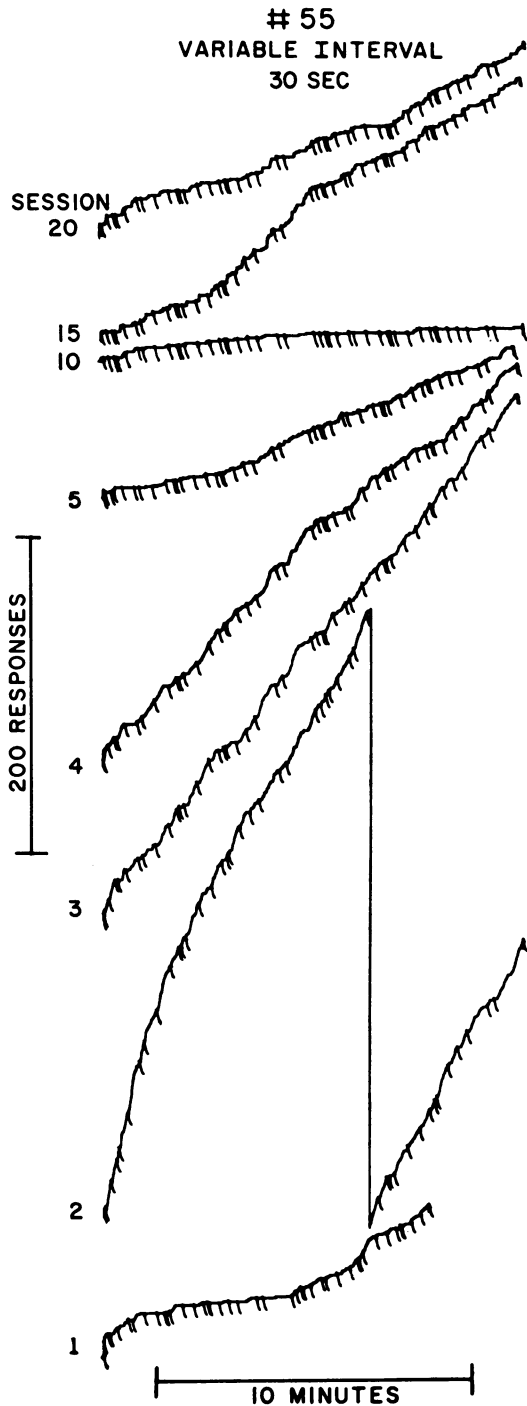


Fig. 2. Selected cumulative records for Subject #55 under the response-independent 30-sec variable-interval schedule in Exp. I. Slash marks denote response-independent reinforcements.

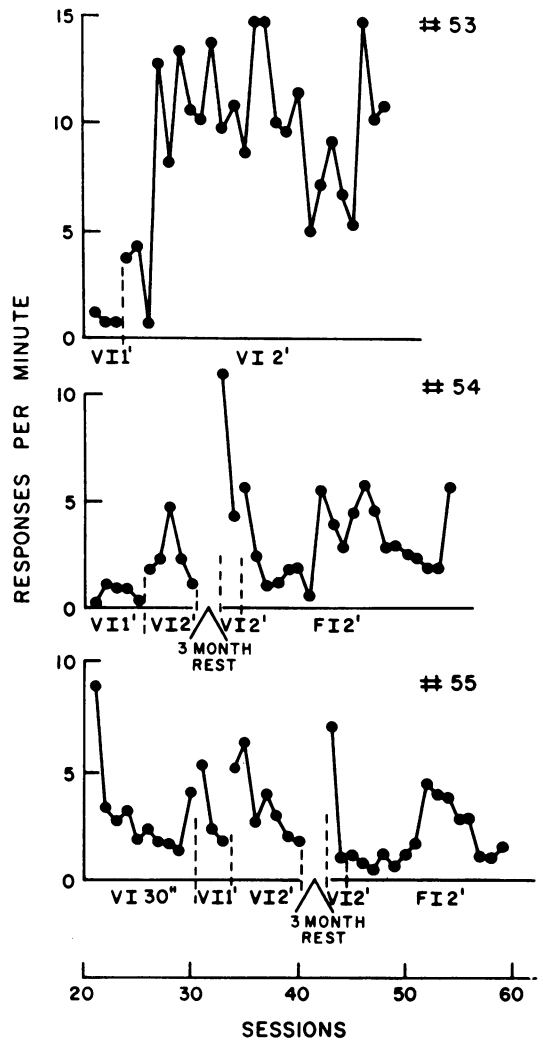


Fig. 3. Rates of responding during each session of Exp. II. Reinforcements were response-independent throughout. See text for explanation of titles on horizontal axis.

## RESULTS

Figure 3 shows the rates of responding for each bird during each session. The most important result, found for all birds, was that responding was maintained throughout. The record of #53 shows, furthermore, that decreasing the frequency of grain from once per minute to once every 2 min resulted in a marked and maintained increase in response rate. Selected cumulative records of this performance are shown in Fig. 4. The negative curvature—a high response rate immediately after grain presentation which decreased with time—seen in these records is representative of all records. Decreasing the frequency of grain caused only transient increases in the rates of responding of Subjects 54 and 55 (see Fig. 3).

Removing #54 and #55 from the experiment for three months and then returning them to a VI 2-min schedule caused 10-fold and four-fold increases in rates of responding, respectively. In both cases, however, the enhancement was transient (see Fig. 3).

Changing the schedule of grain presentation from VI 2-min to FI 2-min produced no dramatic changes in average rates of responding for either #54 or #55: responding was maintained at a low level. Selected cumulative records for #54 under FI 2-min are shown in Fig. 5. A negative curvature is again seen.

Summarizing the results of the two experiments: #53 emitted a total of 22,817 responses over 48 experimental sessions, #54 emitted a total of 8281 responses over 52 sessions, and #55 emitted 9818 responses over 57 sessions.

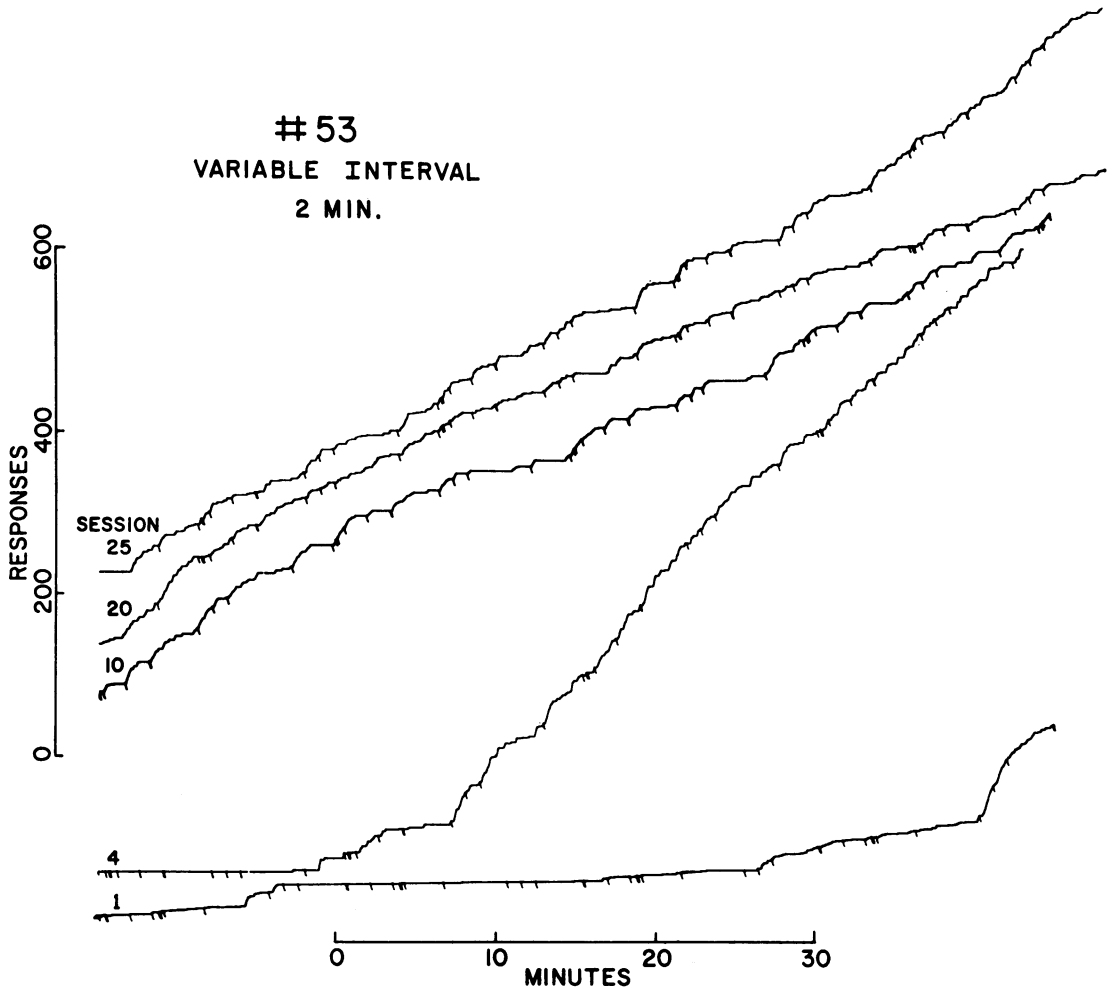


Fig. 4. Selected cumulative records for Subject #53 under the response-independent 2-min variable-interval schedule. Slash marks denote response-independent reinforcements.

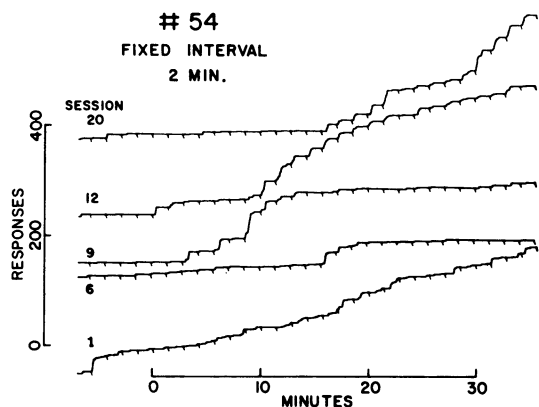


Fig. 5. Selected cumulative records for Subject #54 under the response-independent 2-min fixed-interval schedule. Slash marks denote response-independent reinforcements.

Although responding was variable throughout, and rates of responding were sometimes low, responding did not cease in any session.

## DISCUSSION

When a response produces a reinforcing event, there is an interaction between response and reinforcer: the reinforcer controls the probability of the response and the response controls the occurrence of the reinforcer. This type of response can be called a causal response: it causes, or is instrumental in producing, reinforcement. A different type of response, the superstition, is distinguished by the uni-directional relationship between reinforcing event and response: the reinforcer controls the probability of the superstition, whereas the superstition exerts no control over the reinforcer. Thus, superstitions do not cause reinforcement; they are only adventitiously, or accidentally, reinforced.

Previous research has demonstrated many similarities between causal responses and superstitious responses. First, both are maintained under intermittent schedules of reinforcement, *i.e.*, every occasion of the response need not be followed by reinforcement for the response to be maintained (Ferster and Skinner, 1957; Herrnstein, 1966). Second, both can tolerate delays between response and reinforcement (Skinner, 1938; Skinner, 1948). Third, superstitious as well as causal responses extinguish, *i.e.*, the response ceases to occur when reinforcements are discontinued (Skin-

ner, 1938; Herrnstein, 1966). Fourth, the temporal patterns of both are affected by the temporal patterns of reinforcement (Ferster and Skinner, 1957; Zeiler, 1968). These similarities support Skinner's (1948) contention that a reinforcer need only follow a response (causal or superstitious) to increase the probability of the response; that is, the necessary relationship between response and reinforcer is purely temporal.

The present study extends the area of similarity between the two types of responses. Furumoto (1967) showed that a causal response, the key peck, can be established at relatively high strength by as few as three response-produced reinforcements. The present study demonstrated that an arbitrary superstition, also the key peck, can likewise be established by three response-correlated reinforcements. This last similarity supports Skinner's (1948) analysis of how superstitions are established. According to Skinner, the probabilities of both causal and superstitious responses might be increased by a single temporal correlation between response and reinforcement. If reinforcing events continue, the responses will be maintained. In the present study, three key pecks were followed by grain reinforcement, after which grain occurred independently of responding for approximately 50 experimental sessions; pigeons maintained the key-peck response throughout this time. Moreover, a recent study by Fenner (1969) indicated that a superstition can be established by a single reinforcement.

The rapidity with which superstitions can be established suggests that animals often behave superstitiously. Consider the following two propositions. First, all environments (with the possible exception of the experimental chamber) contain many potential reinforcers that occur independently of responding. For example, rain falls (and might reinforce circle-turning in a water-deprived animal), fruit ripens and falls from a tree, the sun rises, an ice-cream truck appears, a pretty girl asks for directions, *etc.* Second, the number and frequency of conditionable responses in most animals' repertoires are great. This is indicated by the fact that a researcher could reinforce an infinite succession of distinct responses made by any bird or mammal; and observation of any of these animals in their natural environments would similarly demonstrat-

tremendous numbers of learned acts. Since both response-independent reinforcers and conditionable responses are common in most environments, the two will probably often be correlated. And the present experiment demonstrates that a few accidental correlations will establish the response as a superstition. To summarize: (1) response-independent reinforcers occur frequently in most environments; (2) such reinforcers are likely to follow some conditionable response; and (3) for a superstition to be established, a response need be adventitiously correlated with few—and possibly only one—reinforcers.

These considerations suggest that superstitions are commonplace, not relatively infrequent or abnormal events, in an animal's behavioral repertoire. A large proportion of the learned behavior of organisms is therefore superstitious behavior, maintained by events over which the organism has no control. And many of an animal's habitual actions are ineffectual actions. Psychologists attempting to understand and manipulate extra-laboratory behaviors should consider these suggestions.

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